Instruction Book
MODEL 63H
5 Kc/s to 500 Kc/s
Inductance Bridge

BOONTON ELECTRONICS CORPORATION

MDL 63H

Serial Number: 412

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BOONTON ELECTRONICS CORPORATION
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N. J.— 07054

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SECTION I

SPECIFICATIONS

Inductance Measuring Range: 0.0002 μH to 110 mH in 5 steps as follows:

MULTIPLIER	INDUCTANCE RANGE	RESOLUTION OF INDUCTANCE READING
10.0	0 to 110 mH	.01% + 2.0 μH
1.0	0 to 11 mH	.01% + 0.2 μH
0.1	0 to 1100 μH	.01% + 0.02 μH
0.01	0 to 110 μH	.01% + 0.002 μH
0.001	0 to 11 μH	.01% + 0.0002 μH

Inductance Measuring Accuracy: $0.25\% + \frac{300}{C}\% + 0.0002$ μH, where C is the resonating capacitance in pF of the test inductor at the frequency of test.

Series Resistance Measuring Range: 0.0002 ohm to 11K ohms in five ranges as follows:

MULTIPLIER	SERIES RESISTANCE RANGE	ACCURACY
10.0	0 to 11K Ω	$3\% + \frac{Q}{25}\% + 2.0$ Ω
1.0	0 to 1100.0 Ω	$3\% + \frac{Q}{25}\% + 0.2$ Ω
0.1	0 to 110.0 Ω	$3\% + \frac{Q}{25}\% + 0.02$ Ω
0.01	0 to 11.0 Ω	$3\% + \frac{Q}{25}\% + 0.002$ Ω
0.001	0 to 1.1 Ω	$3\% + \frac{Q}{25}\% + 0.0002$ Ω

SPECIFICATIONS (cont'd)

Frequency Range: 5 Kc/s to 500 Kc/s with internal oscillator and detector.

Frequency Accuracy: ± 3%

Note: The accuracy of the test frequency has negligible effect on the accuracy of the inductance measurement.

Frequency Stability: Approximately 0.5% after 30 minute warm-up.

Max. AC Test Level Approximately 3.0 V, RMS, open circuit.

Tube Complement:

Quantity	Type	Used In
1	12AT7	Oscillator
1	6AK5	Pre-amplifier
1	6U8	Tuned Amplifier
2	6AU6	Amplifier
1	6X4	Rectifier
2	0A2	Voltage Regulator
2	2N404A	Emitter-Follower
1	2N1605A	Emitter-Follower
1	2N1046	Emitter-Follower

Power Requirements: 105 to 125V, 50-60 cps, 60 watts, or 210 to 250 volt, 50-60 cps, as specified.

Size: 19-1/4" w x 10-3/4" h x 11-1/4" d; case mounted.

Mounting: Case mounting is standard. Also available for 19-inch rack mounting.

Weight: Approximately 35 lbs.

SECTION II

GENERAL DESCRIPTION

2-1.0. General

2-1.1 The Model 63H is a highly advanced bridge which provides direct reading measurements of series inductance down to low values with fractional percentage accuracy, and under an unusually broad range of test conditions. The instrument also provides direct reading measurement of series resistance. The operational range of the Model 63H is shown in the diagram of Figure 1, page 4. Inductance and resistance ranges are covered in five steps; the frequency range is covered in two decades.

2-1.2 The instrument is completely self contained, including bridge circuitry, variable frequency test oscillator and detector, null indicator, and power supplies. It is packaged as a single, compact bench cabinet. Built on a 19-inch chassis, the Model 63H may be installed in a standard relay rack when the cabinet is removed.

2-2.0. Bridge Circuit

2-2.1 The Model 63H embodies a modified Maxwell circuit (see simplified schematic of Figure 2). The test signal generator and null detection circuit are coupled to the bridge by a technique which constitutes a particularly practical approach to the design of a Maxwell bridge capable of precision measurements over wide ranges of inductance and test frequencies. The two sides of the bridge are driven 180 degrees out of phase by a well balanced low impedance transformer. This permits detection of the balance condition by coupling the detector to the high corners of the bridge through two small, carefully balanced capacitors.

2-2.2 It is characteristic of this bridge circuit that the inductance and resistance arms act independently of each other. By eliminating interaction between the two arms the annoyance and ambiguity of false or sliding nulls is avoided.

2-2.3 Since the bridge is of the non-resonant type, the precision of frequency setting is not critical to the accuracy of measurement. Bridge accuracy is determined primarily by the balancing controls, the precision resistors in the range selector, plus the silvered mica and variable air capacitors comprising the inductance decades. All of these components are adjusted to better than 0.1% accuracy.

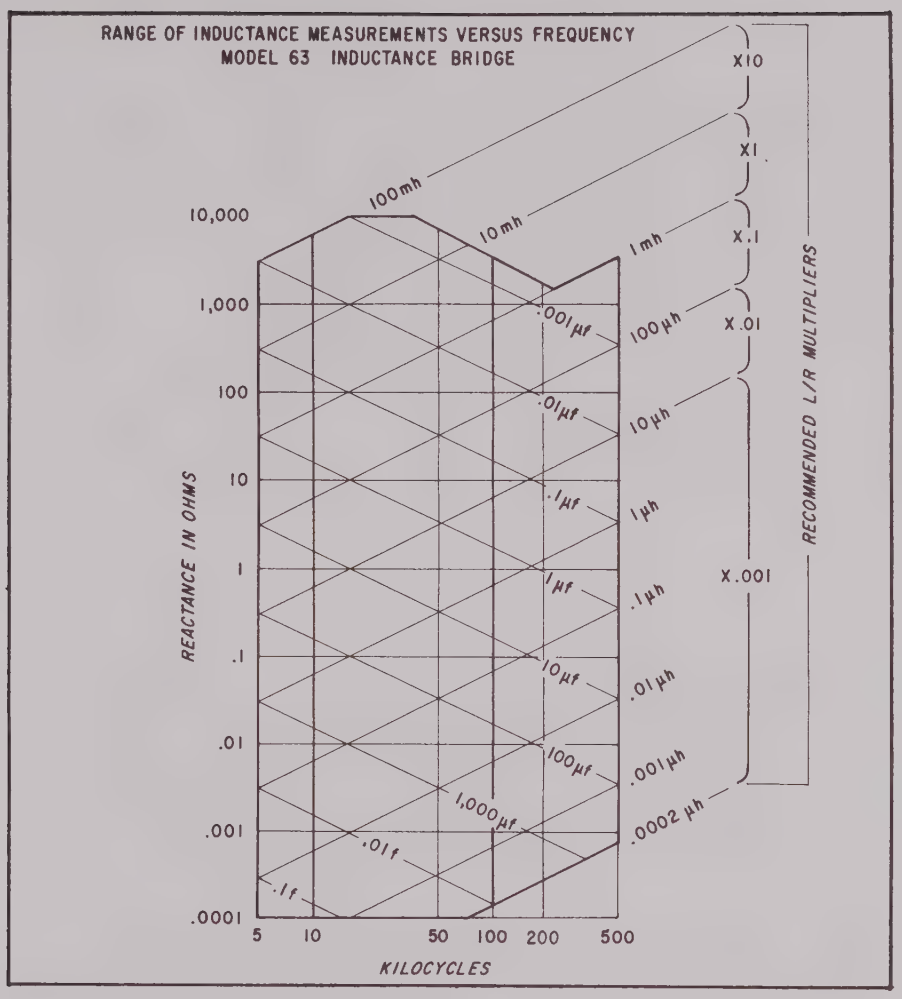


Figure 1

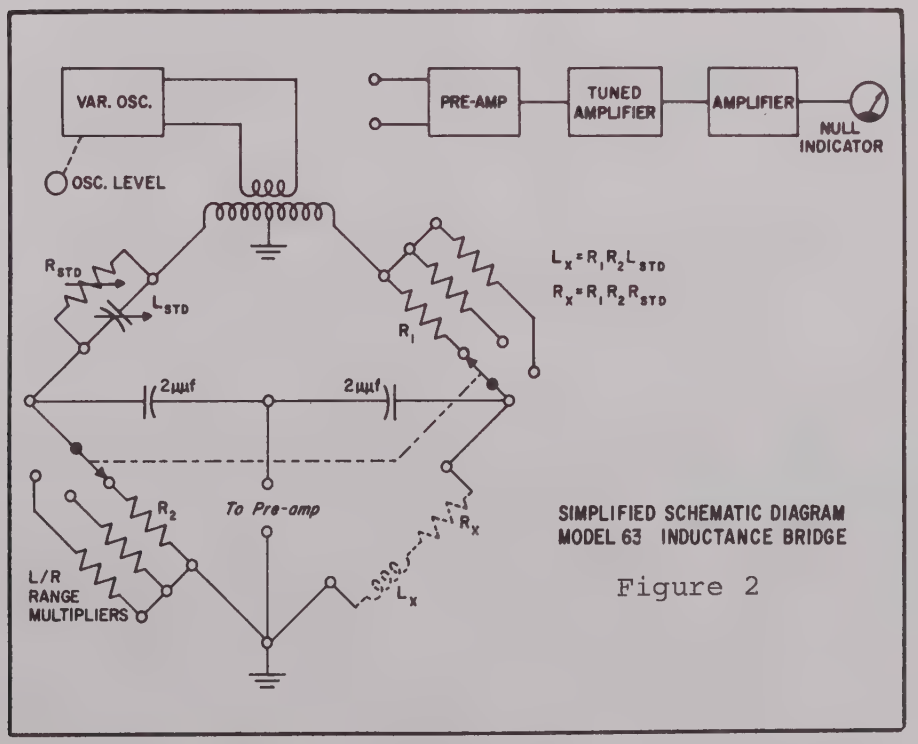


Figure 2

2-2.4 Great care has been taken in both the electrical and mechanical design of the Model 63H to compensate or eliminate the sources of residual error that commonly restrict the accuracy of measurement of bridges operating at these frequencies.

2-2.5 The excellent scale readability of the Model 63H allows full advantage to be taken of the instrument's capability for high precision and resolution. The combination of the outer "counter dial" and inner 20-to-1 vernier displays the total inductance measuring range across a scale effectively more than 850 inches long. This dial arrangement also assures convenient rapid scanning to locate the null, as well as accurate fine adjustment.

2-3.0. Null Detector

2-3.1 As shown in Figure 2, the null detector is coupled to the bridge at the high corners through two balanced capacitors. The untuned high impedance preamplifier prevents bridge loading and contributes to the overall system sensitivity. Adjustment of the tuned detector is independent of the test signal generator control so that the amplifier may be critically tuned without altering the test frequency.

2-3.2 Frequency response of the final wide band detector amplifier is essentially flat over the total frequency range of the instrument. It has a maximum gain of 65 db for a total detector system gain of approximately 105 db.

2-3.3 Output from the wide band amplifier is passed through a half wave rectifier, compressed, and then metered. System sensitivity is further enhanced by use of a 50 microampere taut band meter for null indication.

2-3.4 The ac component of the rectified output from the wide band amplifier is also available at a rear jack for connection of an oscilloscope or other remote indicator.

2-4.0. Test Signal Oscillator

2-4.1 The internal test signal oscillator is continuously adjustable in frequency from 5 Kc/s to 500 Kc/s. Accuracy of frequency setting is 3%. As stated above, in this bridge circuit precision of test frequency setting is not critical to the accuracy of measurement. However, in the rare circumstance in which more accurate frequency adjustment is required, the test signal may be monitored with a counter and set more precisely. Stability of the test frequency is better than 0.5%.

2-4.2 The test signal level is continuously adjustable by means of a front panel control and may be monitored at the test terminals with a high impedance electronic voltmeter. Maximum open circuit level is 3 volts. Test current may also be monitored by means of a "clamp-on" type probe and a sensitive ac current meter. (See paragraph 3-4.4)

2-4.3 The test current is independent of the balance condition of the bridge, a fact of considerable importance in applications involving such components as ferrite cores, since their permeability varies with the level of excitation current. Were the test current to change from the known level during balancing, meaningful measurements would be impossible.

2-4.4 A dc current may be superimposed on the test signal if desired. However, since the dc current also flows through the bridge circuit, the maximum levels indicated for each range in Table 7 on page 17 should not be exceeded. This prevents exceeding the power dissipation limits of the bridge components.

SECTION III

OPERATING PROCEDURE

3-1.0. General

3-1.1 This section describes in detail the operating procedure of the model 63H Inductance Bridge. All information required for safe and proper operation of the instrument is included. BE SURE TO READ THIS SECTION BEFORE PLACING THE INSTRUMENT INTO OPERATION!

3-2.0. Turn-On Procedure

Step a. Before plugging the instrument into an appropriate outlet, make sure the power source is 105-125 volts, 50-60 cp/s, unless otherwise specified on the instruments identification plate.

Step b. Plug the instrument into the power outlet.

Step c. Set toggle switch to ON and allow a warm-up period of approximately two minutes (one hour or more after high humidity exposure or after long exposure to low temperature).

3-3.0. Measurement Procedure

Step a. Connect the short circuit plug (or strap) supplied with the instrument across the TEST binding posts.

PRECAUTION

When using the X0.001 position of the L/R MULTIPLY switch, the short circuit strap supplied with the bridge must be used for zeroing the bridge; on all other ranges the short circuit plug may be used. If the shorting plug is used for the X0.001 range it may not be possible to zero the bridge.

Step b. Set oscillator range switch to either X1 or X10 position, depending upon required test frequency. Use X1 if frequency is below 50 Kc/s; otherwise use X10 position. Please Note: This "Range Selector" also selects desired range for the Tuned Detector. Refer to Figure 1 to determine that both frequency and inductance fall within boundary area shown. For greater accuracy, refer to accuracy statement on page 1.

Step c. Set MULTIPLY L/R switch to range recommended in table for Inductance under test. (See page 10)

Table 1

INDUCTANCE	MULTIPLY "L" AND "R" BY
0.0 to 11 μH	0.001
11.0 to 110 μH	0.01
110.0 to 1100 μH	0.1
1.1 to 11 mH	1.0
11.0 to 110 mH	10.0

Step d. Set both SERIES INDUCTANCE dials to read zero and both SERIES RESISTANCE dials to read zero.

Step e. Set OSC. LEVEL control to the "RED LINE" position

NOTE: The red line on the oscillator level control indicates approximately one-half of its rotation. This is adequate for most measurements. If a higher test level is desired, it may be used at full rotation except on the X0.001 range where the "RED LINE" position should not be exceeded. Operating with a higher level on this range may cause overheating of the bridge resistors with resultant change in bridge accuracy and possible damage to components.

Step f. Set SENSITIVITY control to maximum.

Step g. Adjust DETECTOR TUNE control until null indicator deflection is a maximum. To avoid tuning the detector to a harmonic of the test frequency, the detector should be tuned to the peak which occurs in the FARTHEST COUNTER-CLOCKWISE POSITION of the detector tuning knob (the low-frequency end of the multi-turn control).

Step h. Alternately adjust the ZERO ADJUST (L) control and the ZERO ADJUST (R) controls until the null indicator deflection is at a minimum point.

NOTE: The "L" zero control has a vernier control with a dual ratio. When this control is turned rapidly, the drive ratio is 6:1. For fine tuning, as the null is approached, and the control is slowly rotated, the ratio is 36:1. It will be noted that far less torque is required for the 36:1 fine tuning than for the 6:1 rapid scanning.

The "R" zero adjustment consists of two separate controls; "COARSE" for rapid scanning, and "FINE" for precise adjustment in locating the null.

Step i. After obtaining minimum deflection of the null indicator it is usually desirable to adjust the sensitivity control to reduce the residual noise level. Leaving all other controls undisturbed, adjust the sensitivity control until a reading of one and one half (1 1/2) meter divisions is obtained. This sensitivity level is adequate for the vast majority of applications. It minimizes the effects of the total system noise, and in addition, experience has shown that it is more convenient to locate a null with low meter readings rather than at half scale or above.

Step j. Remove short circuit from across TEST binding posts and connect the test specimen.

Step k. Adjust SERIES INDUCTANCE "1000 μH" decade switch for minimum deflection of the null indicator. Adjust the MICROHENRIES dial to obtain a lower null indication. If null deflection is not reduced then set this decade switch to next lower position and re-adjust MICROHENRIES dial for minimum deflection.

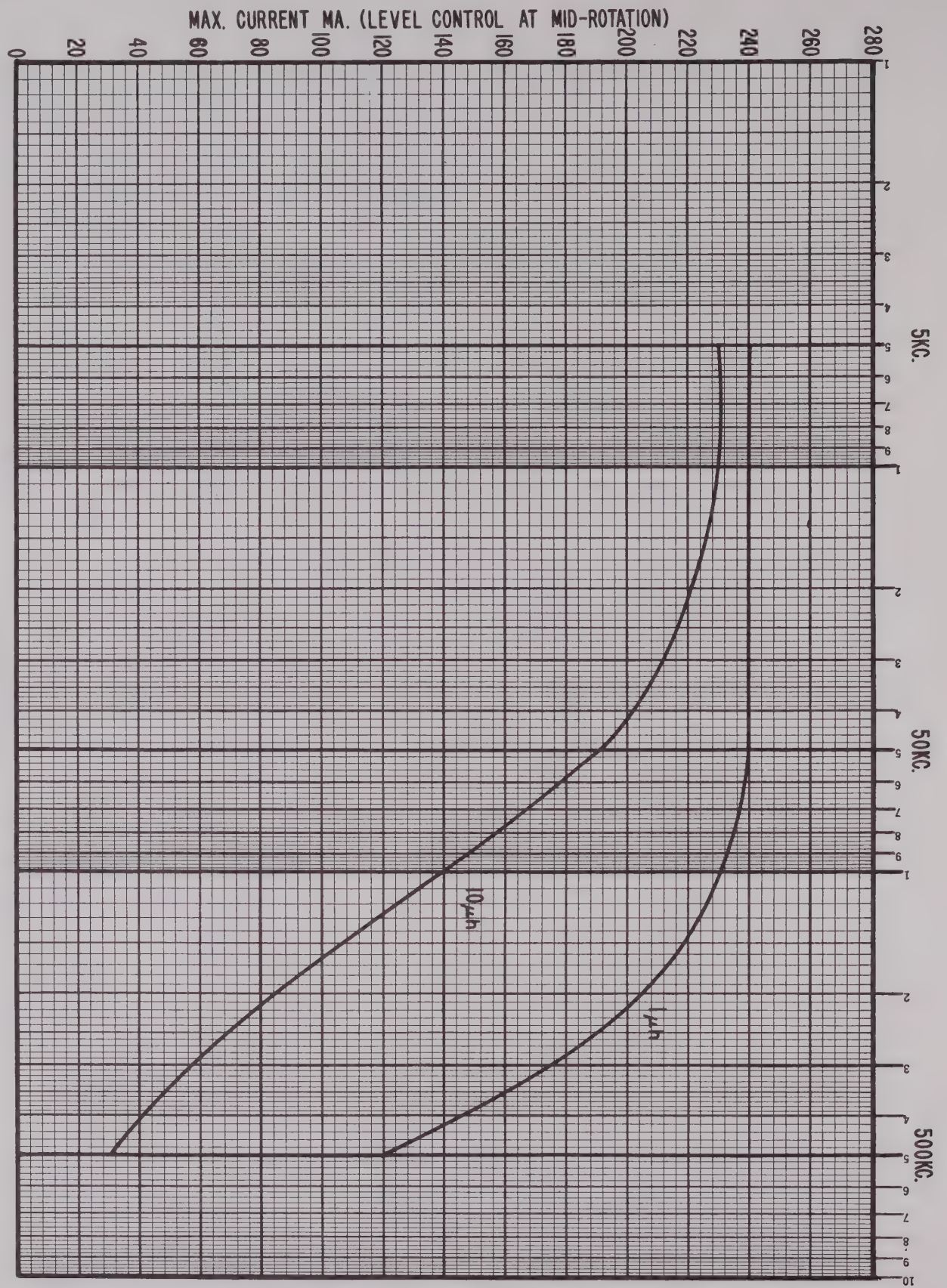
Step l. Now adjust OHMS dial to obtain further reduction of null indication. Use "100Ω" decade switch if necessary.

Step m. Now alternately adjust MICROHENRIES dial and OHMS dial until null indicator deflection is an ABSOLUTE minimum.

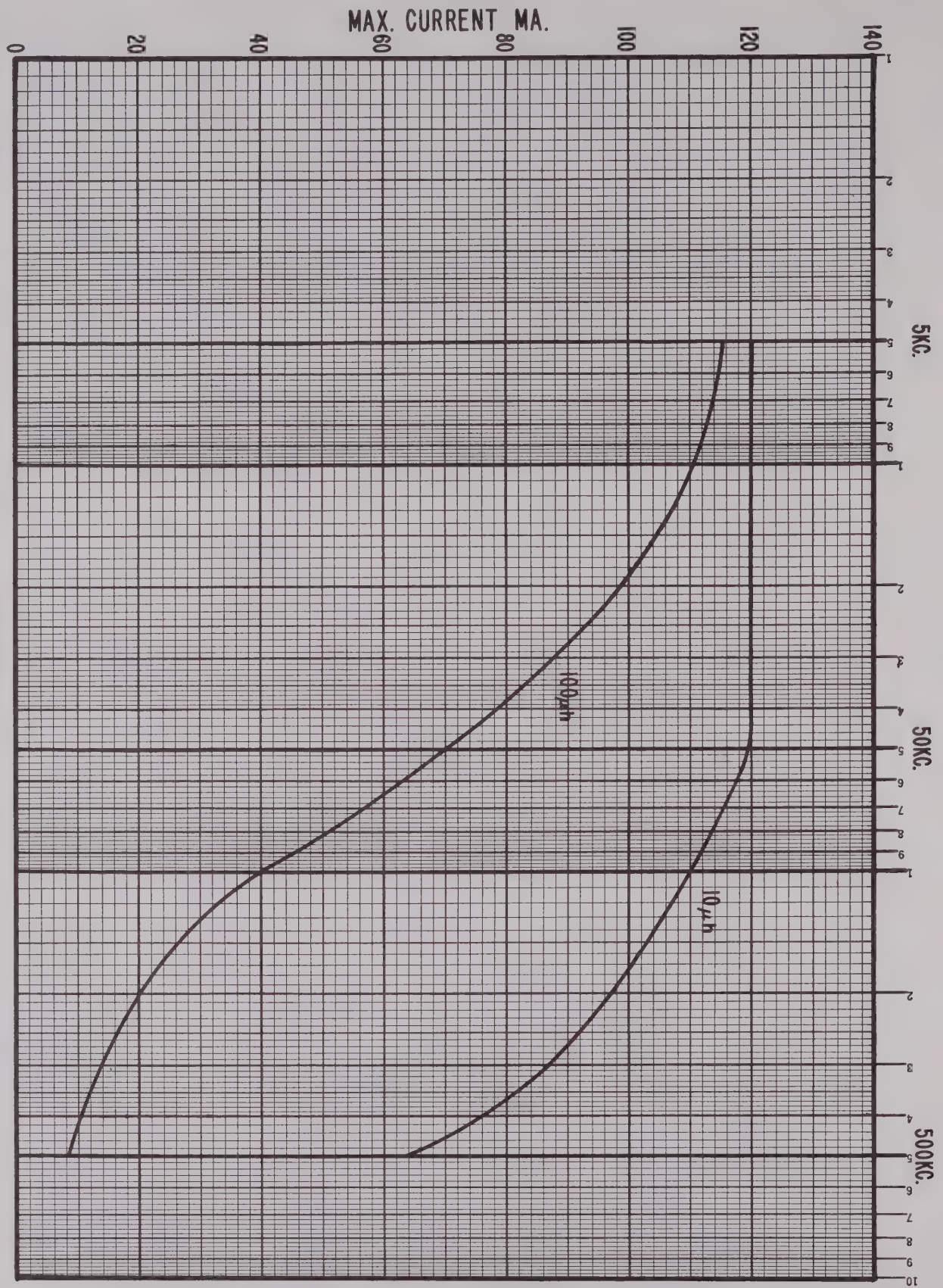
Step n. To obtain the value of inductance under test, add the readings on the two SERIES INDUCTANCE dials and multiply by the factor indicated on the MULTIPLY L/R dial.

Example:

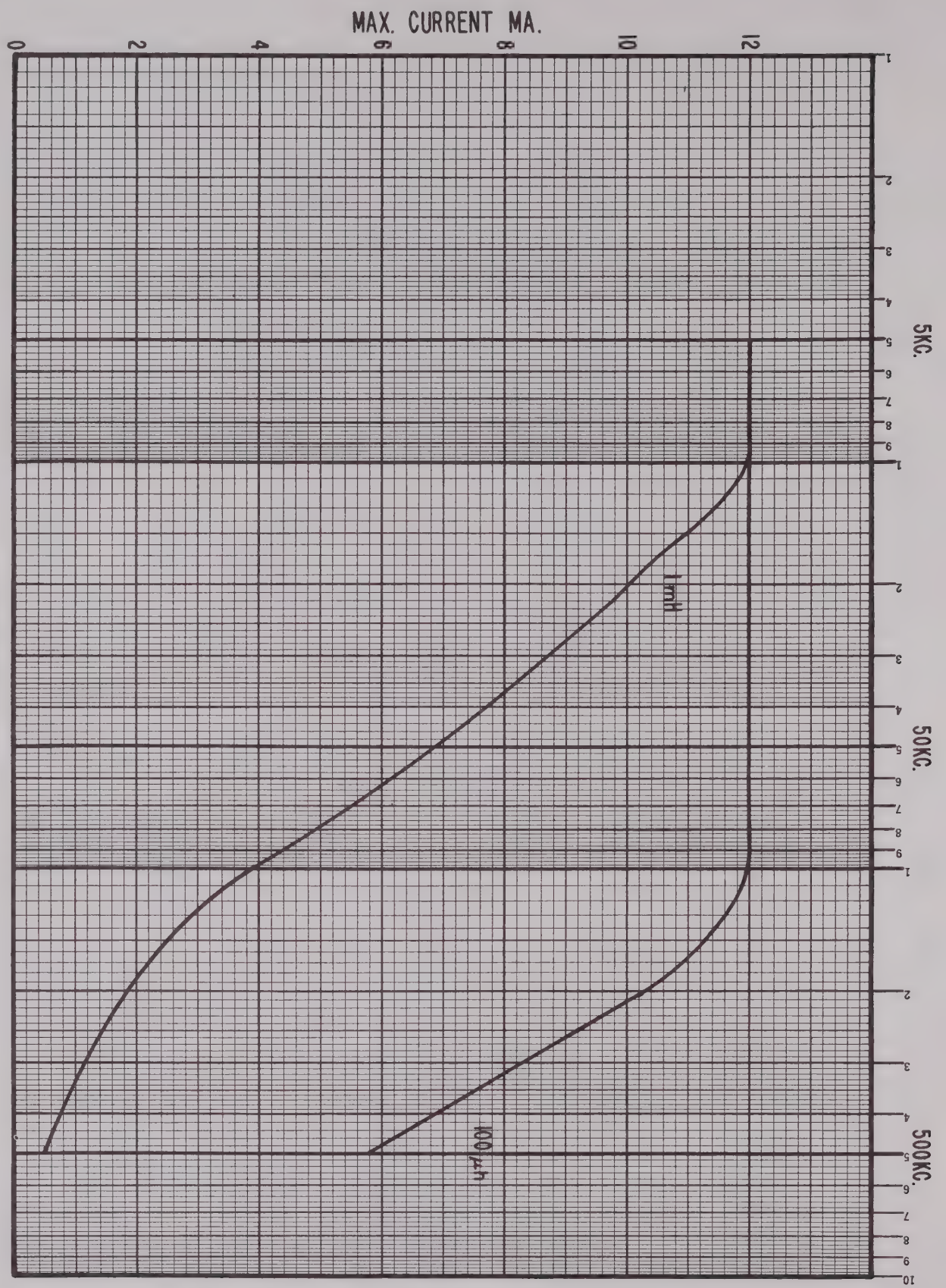
Reading on 1000 μH dial	= 3000.0 μH
Reading on MICROHENRIES dial	= 437.5 μH
Sum	= 3437.5 μH
MULTIPLY L/R dial	= 0.1
Inductance of coil under test	= 343.75 μH



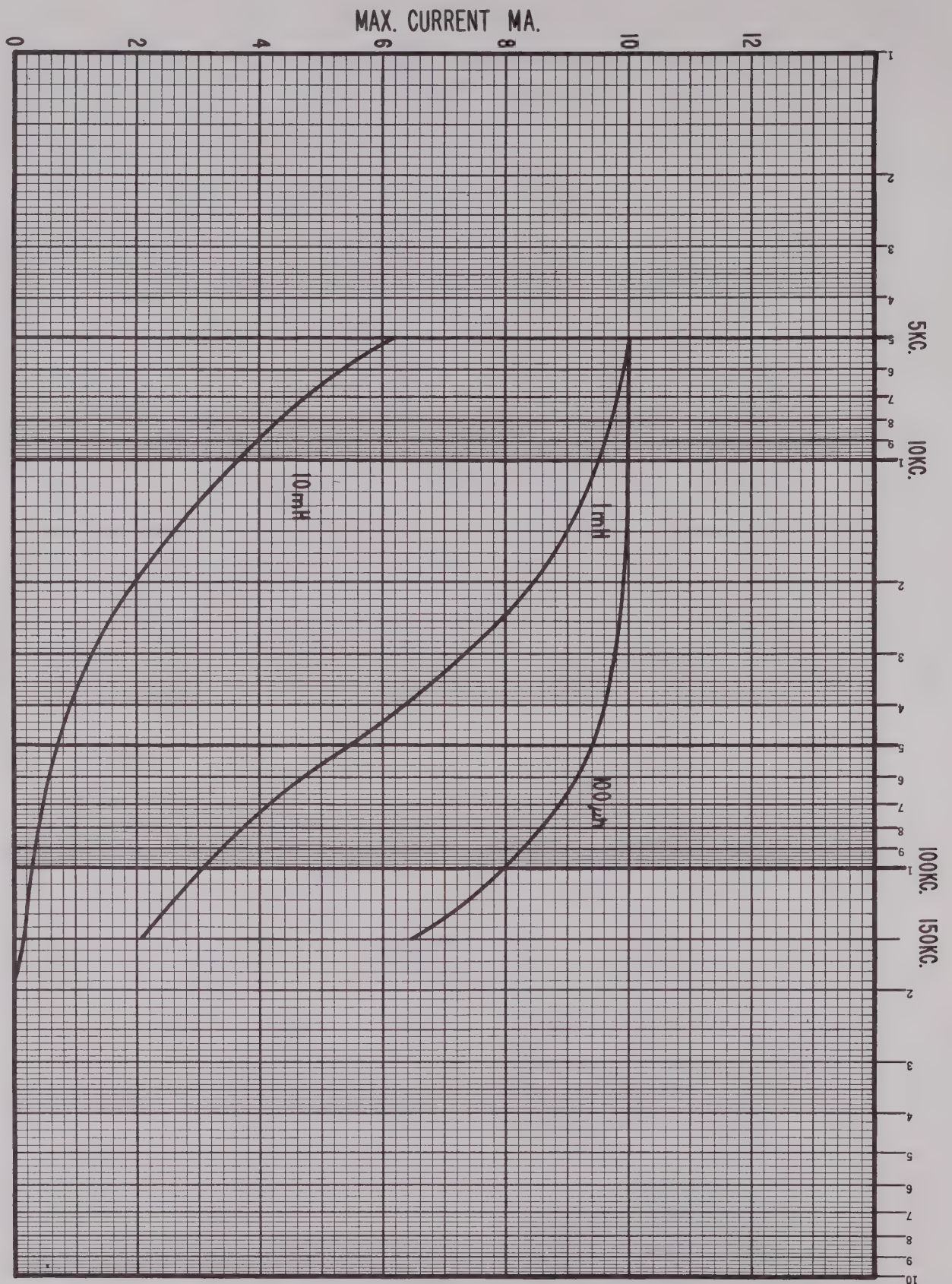
63H MAXIMUM AC TEST CURRENT X0.001 RANGE



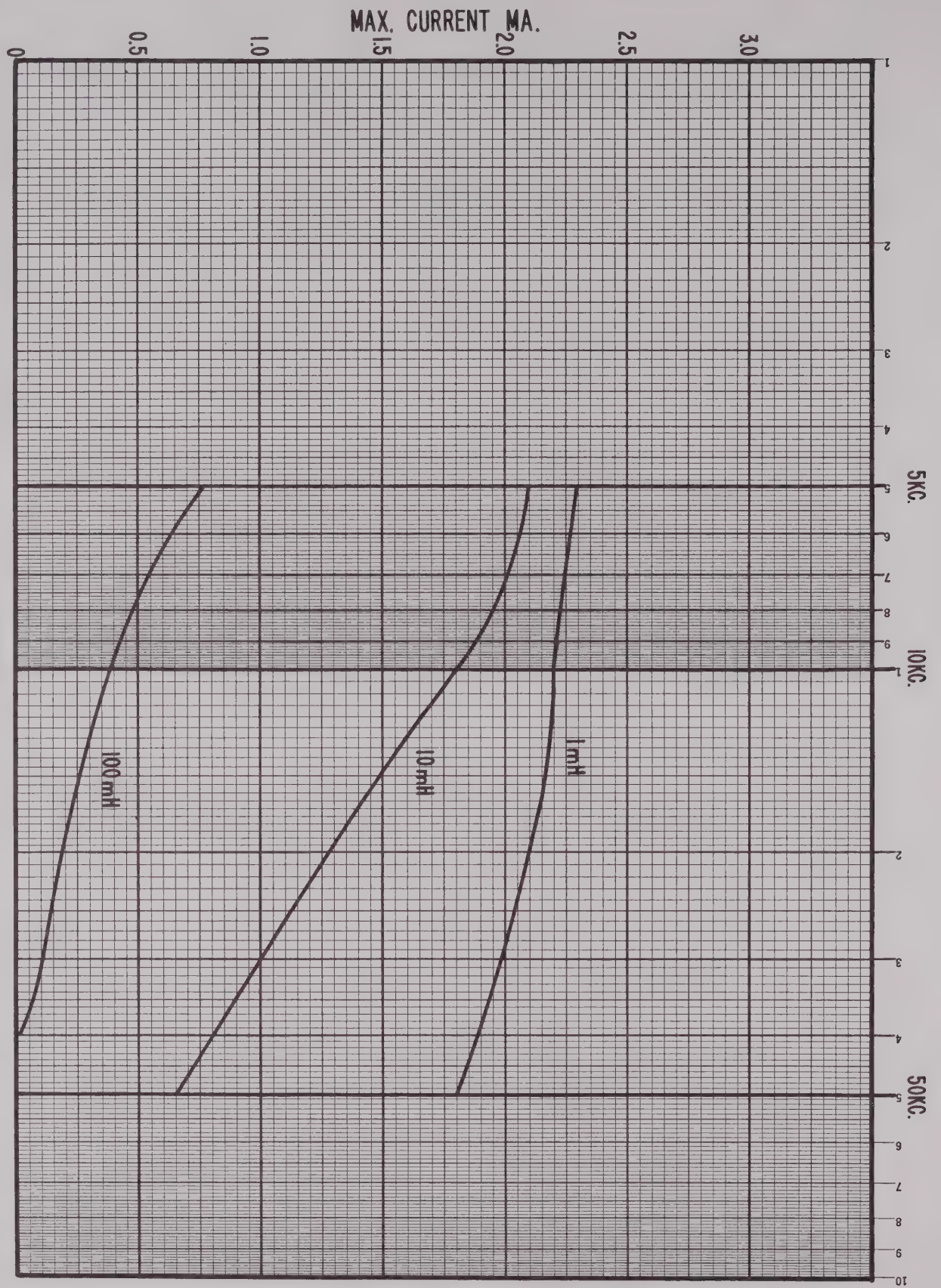
63H MAXIMUM AC TEST CURRENT X0.01 RANGE



63H MAXIMUM AC TEST CURRENT X0.1 RANGE



63H MAXIMUM AC TEST CURRENT X1 RANGE



63H MAXIMUM AC TEST CURRENT X10 RANGE

Step o. To obtain the value of series resistance under test, add the readings on the two SERIES RESISTANCE dials and multiply by the factor indicated on the MULTIPLY L/R dial.

Example:

Reading on 100Ω dial	= 0.0Ω
Reading on OHMS dial	= 64.0Ω
Sum	= 64.0Ω
MULTIPLY L/R dial = 0.1	
Resistance of coil under test	= 6.4Ω

3-4.0. AC Test Voltage and Current Measurements

3-4.1 The ac voltage across the test specimen or the ac current passing through the test can be adjusted from zero to maximum by means of the OSCILLATOR LEVEL control. Maximum open-circuit test voltage is approximately 3.0 volts (RMS) on all ranges except on the X0.001 range, where it is approximately 1.5 v.

3-4.2 Precaution: When operating on the X0.001 RANGE the oscillator level control should not be set beyond approximately the "RED LINE" position in order to avoid possible distortion of the test signal, and also to prevent heating of resistors in the bridge which might cause drift in null indication.

3-4.3 The voltage appearing across the test at balance can be measured by a high impedance vacuum tube voltmeter.

3-4.4 The current through the test may be determined with a clip-on type AC milliammeter. It may also be determined by measuring the voltage drop across a one ohm resistor connected between the GND terminal and the specimen under test. The current in milliamperes can thus be read directly in terms of millivolts across the one ohm resistor. However, if the latter method is used, the one ohm of resistance must be subtracted from the indicated Series Resistance to obtain the correct value.

3-4.5 Maximum ac test Current values versus frequency for each range are shown in the charts on pages 13 to 17.

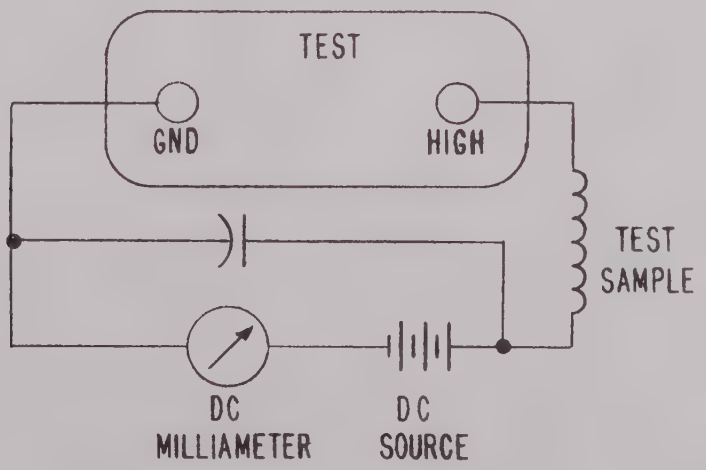
3-5.0. Application of Superimposed DC Current

3-5.1 Superimposed DC current may be applied to the coil under test within the maximum limits indicated in the following table.

PLEASE NOTE: Values shown in this table are the maximum DC levels that may be superimposed on the full AC level without overheating the bridge resistors. Exceeding the value for any given range could cause heating of the bridge resistors, with resultant null drift, or altered bridge calibration, if the overload is prolonged or substantially beyond specified limits, extensive damage to bridge components could result.

MULTIPLY L/R RANGE	MAX, DC CURRENT Milliamperes
0.001	300
0.01	150
0.1	70
1.0	70
10.0	50

3-5.2 The DC current source and milliammeter should be connected between the GND binding post and the low side of the test. (See accompanying diagram.) An extremely high-capacitance electrolytic capacitor of adequate voltage rating should be connected across the DC source and milliammeter to minimize errors resulting from this series impedance. This impedance may also be measured and the values subtracted from the final measurement.



SECTION IV

MAINTENANCE

4-1.0. Circuit Checks

The following information is given to aid in trouble shooting the various circuits of the bridge as well as to determine if all circuits are operating properly.

Voltage measurements either AC or DC are made from the indicated point to chassis ground with a 20,000 Ω/voltmeter such as a Simpson #270 or equivalent. The voltages are nominal and may vary slightly between units due to component tolerances. Voltage measurements are made at nominal line voltage and under full load conditions.

4-2.0. Voltage Measurements

4-2.1 Power Supply

V201 6BW4 - Rectifier tube voltage readings.

Pin #1	380v AC	Pin #7	380v AC
Pin #4	6.3v AC	Pin #9	+425v DC

Junction of L201, C202b & R202	+415v DC
Junction of D205 and D206	5.5v AC
Junction of D207 and D208	5.5v AC
Junction of D201 and D202	15v AC
Junction of D203 and D204	15v AC
Junction of D201, D203 & C201	-34v DC

Voltage measurements made at the 12 pin connector, J201, are as follows:

Pin #3	+300v DC	Pin #7	6.3v AC
Pin #4	+300v DC	Pin #8	-6.6v DC
Pin #5	+150v DC	Pin #9	+6.6v DC
Pin #6	6.3v AC	Pin #11	-11.5v DC

The total power from the AC line, with a nominal line voltage of 120 volts, should be 60 watts as measured with a Sensitive Research, Model Univ. wattmeter.

4-2.2 Oscillator

Oscillator tube voltage readings V101 12AT7

Pin #1	+200v DC	Pin #7	0v
Pin #2	0v	Pin #8	+1.7v DC
Pin #3	+2.9v DC	Pin #9	6.3v AC
Pin #6	+156v DC		

The total B+ current drawn by the oscillator under normal conditions should be 7 ma.

The following are nominal AC voltages taken at the junction of R107 and R108 with a Ballantine 314 VTVM:

X1 Range:	5Kc	6.6v	25Kc	6.2v
	10Kc	6.4v	50Kc	6.2v
X10 Range:	50Kc	6.4v	250Kc	6.2v
	100Kc	6.4v	500Kc	6.2v

4-2.3 Emitter Follower

The following are nominal DC voltages throughout the emitter follower circuit. CAUTION In making voltage measurements it is absolutely necessary not to short the test lead to ground from any point being measured.

A101	2N404A	Emitter	-21.5 volts	
		Base	-21.0 "	
		Collector	-34 "	Supply
Q102	2N404A	Emitter	-21.5 "	
		Base	-21.5 "	
		Collector	-34 "	Supply
Q103	2N1605	Emitter	-21.5 "	
		Base	-21.5 "	
		Collector	-18.0 "	
Q104	2N1046	Emitter	-21.0 "	
		Base	-21.5 "	
		Collector	-34 "	Supply

4-2.4 Tuned Detector

Tuned detector tube voltage readings. V501 6U8

Pin #1	+130v DC	Pin #6	+85v DC
Pin #2	0v	Pin #7	+1.3v DC
Pin #3	+90v DC	Pin #8	+6.2v DC
Pin #4	+6.6v DC	Pin #9	0v
Pin #5	Ground		

4-2.5 Preamplifier

Preamplifier tube voltage readings. V401 6AK5

Pin #1	0v	Pin #5	+21v DC*
Pin #2	No pin	Pin #6	+60v DC*
Pin #3	Ground	Pin #7	+1.5v DC*
Pin #4	-6.6v DC		

*These voltages are with no signal input and will vary widely with signal input.

4-2.6 Wideband Amplifier

The following voltage readings are made with Sensitivity Control at maximum gain and no input signal.

V601	6AU6		
Pin #1	0v	Pin #6	+178v DC
Pin #4	6.3v AC	Pin #7	+2.5v DC
Pin #5	+185v DC		
V602	6AU6		
Pin #1	0v	Pin #6	+150v DC
Pin #4	6.3v AC	Pin #7	+4v DC
Pin #5	+208v DC		

Wideband amplifier gain vs frequency.
Input Level - 0.001v
Gain Controls - Maximum

Freq.	Input Level	Output Level	Gain in db.
5 Kc	0.001v	1.9v	65.5 db
10 Kc	0.001v	1.9v	65.5 db
50 Kc	0.001v	1.9v	65.5 db
100 Kc	0.001v	1.9v	65.5 db
500 Kc	0.001v	1.0v	60.0 db

Input level measured at J601
Output level measured at C612, C613 and D601

4-3.0. Calibration and Adjustment of Oscillator and Tuned Detector

4-3.1 The oscillator dial has one calibration of from 5.0 to 50 and with the use of the X1 and X10 multiplier the frequency is covered in two ranges of from 5 Kc to 50 Kc and 50 Kc to 500 Kc. The accuracy of calibration is ±3% and should be maintained. Errors in low frequency calibration may be due to changes in the resistors R101, R102, R103 and R104. High frequency calibration may be adjusted by C104 adjustment #1.

4-3.2 Tuned Detector Adjustment

Before adjustment of the tuned detector, the cover over the oscillator-detector chassis as well as the preamplifier must be in place and all screws tightened.

Disconnect the power plugs J602 and P602 to the wideband amplifier, also J101 and P101 to the oscillator section.

Use a coaxial "T" connector at J601, the input to the wideband amplifier for connecting a VTVM such as a Ballantine 314 and an oscilloscope. Long coaxial leads should not be used because of the added capacity. The input of the wideband amplifier should not be disconnected.

Set the L & R multiply switch S303 to the X0.1 range.

Feed an oscillator with a frequency range of 5 Kc to 1 Mc into the bridge "TEST" terminals through an attenuator, the input at the "test" terminals should be monitored and kept at 0.01 volts, with a Ballantine 314 or equivalent.

Set the frequency multiply switch S501 to the X1 position, set oscillator to 5 Kc and alternately adjust detector tune control and adjustment #6 for 7 volts output. Check discrimination at 10 Kc which should be down approximately 43 db.

Set oscillator to 50 Kc, maintaining 0.01v into the bridge test terminals, alternately adjust the detector tune control and adjustment #3 for 3 volts output. Check discrimination at 100 Kc which should be down approximately 37 db.

Now recheck between 5 and 50 Kc and readjust #6 and #3 until these readings are obtained with no oscillations.

Set the frequency multiply switch S501 to the X10 position, set the oscillator to 50 Kc and 0.01 volts input. Alternately adjust the detector tune control and adjustment #5 for 3 volts output. Check discrimination at 100 Kc which should be down approximately 37 db.

Set frequency to 500 Kc, with input level maintained at 0.01 volts. Alternately adjust the detector tune control and adjustment #2 for 3 volts output. Check discrimination at 1 Mc which should be down approximately 37 db.

Now recheck between 50 and 500 Kc and readjust #2 and #5 until these readings are obtained with no oscillations. It may be necessary to remove the cover to adjust C504 #4 at 500 Kc in order to obtain only one tuning point with no oscillation.

The residual noise level on both ranges should not exceed 0.003 volts.

4-4.0. Bridge Section Adjustments

NOTE: CAUTION Adjustments to the bridge section and L-R multiply switch should not be made if at all possible. Such adjustments are preferably factory made. The following information is primarily for determining the proper functioning of the bridge.
Replacement and movement of components in the bridge section may result in bridge inaccuracies.

4-4.1 Variable Capacitor Calibration (C302)

The variable capacitor should be checked with a 20 Kc capacitance bridge. The bridge circuit should be opened at A' which is the wire braid to the ceramic standoff in the bridge section. Also the lead to the bridge input transformer T301 should be opened at B. The resistor R302 (14K) should be opened where it connects to R301. (Reference schematic 830183.) Switch S302 (Inductance Decade) should be set on zero. The leads to the L and R zero controls need not be opened. C301 should be set at minimum capacity and R304 set at maximum resistance. R306 should be set near maximum resistance but may be used as a fine conductance adjustment, the same as the capacitance bridge conductance zero adjustment.

The first 200 (100 pF) dial divisions of the capacitor should be calibrated every 10 divisions (5 pF) and must be within $\pm$0.1 pF. This should be done on the X0.1 range of the capacitance bridge. The remaining 800 dial divisions may be calibrated every 100 divisions (50 pF) and may be done on the X1 range. All readings must be within $\pm$0.1%.

Care should be taken to keep leads as short as possible when connecting the capacitance bridge to the inductance bridge; all clip leads should be kept as far from the variable capacitor as possible, so when all calibration is complete, removing the leads will not affect the calibration.

In calibration of the first 200 dial divisions, it will be necessary to return to zero and recheck after almost every plate adjustment as the minimum capacity will be changed considerably over the first part of the calibration.

4-4.2 Inductance Decade Switch Calibration (S302)

The arrangement of leads for calibration of the decade switch can be the same as for the variable capacitor calibration. However, a bridge shield cover, with holes for adjustment purposes should be used to insure the best accuracy. The variable capacitor should be set on zero.

The first position (1000μH) the capacity should be 500 pF $\pm$0.1% and adjusted by #10 (C304).

Position #2 (2000μH) should be 1000 pF $\pm$0.1% and adjusted by #13 (C311).

Position #3 (3000μH) should be 1500 pF $\pm$0.1% and adjusted by #9 (C303). This position is a combination of capacitors - C304, C305 and C310, C311.

If an error is indicated on this position, read the value of error and reset the capacitance bridge to zero offset by the amount of error and in the opposite direction; that is, if the capacitance is 2 pF high, set the bridge at minus 2 pF

from zero and adjust #9 (C303) for zero. Return bridge to zero, rebalance and recheck positions 1, 2 and 3. Repeat this procedure until each position is within ±0.1% of nominal.

Position #4 (4000μH) should be 2000 pF ±0.1% and adjusted by #12 (C309).

Position #5 (5000μH) should be 2500 pF ±0.1% and adjusted by #11 (C306).

The remaining positions are each an increase of 500 pF and have no adjustments. If each capacitor is properly adjusted from position 1 to 5, each remaining position should check as follows:

#6	3000 pF	±0.1%
#7	3500 pF	±0.1%
#8	4000 pF	±0.1%
#9	4500 pF	±0.1%
#10	5000 pF	±0.1%

Restore all connections within the bridge section.

4-4.3 Balance Capacitor Adjustment (C315)

It is necessary to balance the circuitry associated with the balance capacitor C315 to obtain correct adjustment during the further calibration procedures. The L-R Multiply switch should be set on the X0.01 position, and the bridge should be tuned and operating at 10 Kc. The bridge circuit should be opened at point D, also the bridge test terminals must be open. The rotor of the variable capacitor (C302) should be shorted to the stator with a short lead. Then by alternately adjusting #19 and #20 on the balance capacitor, a minimum meter reading will be obtained. The meter will not indicate zero at the null but there will be a definite null condition. Care in making this adjustment will make further adjustments unnecessary.

4-4.4 Resistance Decade Check and Resistance Dial S301 and R301)

Set the L-R Multiply switch to X1.0 with the resistance dial set on zero and a General Radio 1432T decade resistance box connected to the bridge test terminals. Check each 100Ω position of the resistance decade switch from one hundred to one thousand ohms. Each position must be within 0.5%. Repeat this procedure with resistance dial.

4-4.5 Product Arm Adjustment (L and R Multiply Switch)

The adjustment of the product arm is made on a d.c. resistance measurement basis. A resistance bridge accurate to five places is required. The three leads to the resistance bridge should all be the same length. The resistance of the leads should be measured and used as a correction factor. One lead should be connected between the ground side of the resistance

bridge and a ground on the inductance bridge preferably where the rear section of the L-R switch is connected to ground. The other two leads should be each of a different color to identify them and one should be connected to point A on the rear of the L-R switch; the other lead will be connected to point C either in the L-R switch or at the balance capacitor. The lead from A' to the bridge section should be opened where it leaves the L-R switch. The bridge test terminals must also be open; that is, no shorting plug should be connected. Now it will be possible by connecting either the A or C lead to the high post of the resistance bridge to measure the d.c. resistance from A to D or C to D. All solder connections must be carefully made to insure no high resistance connections which could have considerable error in the measurements. Extreme care should be used in making the measurements, as well as reading the values on the bridge and making the necessary calculations to insure the best possible accuracy in these measurements. The rotation of the X0.001 down to the X10 range should be followed. The X0.001 and X10 range have separate resistors which are not dependent upon another range; however, the X0.01 to the X1 range should be adjusted in that order as each is dependent on the value of the other.

The procedure to be followed, for example, on the X0.001 range is as follows. First the resistance is measured from CD which will be in the area of 5 ohms. The correction factor which is the resistance of the leads will be subtracted from this value. This gives a corrected value for CD. On the X0.001 range the product of the bridge arms CD x AD is 2×10^3. The value of 2×10^3 should be divided by the corrected value of CD to obtain AD. To this value is added the correction factor (lead resistance) to obtain a value of AD, which is then set up on the resistance bridge with the appropriate leads and adjustment 14 is varied to obtain this reading. This procedure should then be followed for the remaining four ranges.

4-4.6 Adjustment of Zeroing Controls

The bridge should be capable of being zeroed on every range at every useable frequency. The X0.001, X0.01 and X0.1 range should be able to be zeroed at any frequency, the X1.0 range should be able to be zeroed to at least 250 Kc and the X10 range should be zeroed up to 100 Kc. If the bridge will not zero on any particular range, a check should be made to determine if the proper shorting connector is being used. On the X0.001 range it is necessary to use the shorting link supplied; on the other ranges, the shorting plug supplied should be used. Using the proper shorting connectors, the bridge should zero over the frequency range given above. To locate troubles in

zeroing, the main controls may be used to zero the bridge which will show the approximate magnitude and if the fault is due to inductance or resistance.

4-4.7 Bridge Sensitivity and Noise Level

With the front panel sensitivity control at maximum gain, the noise level should not exceed 10μA at any frequency. Any higher noise level indicates either a noisy 6AK5, V401 or the tuned detector is adjusted near a point of oscillation thereby increasing the noise.

The following are nominal sensitivity checks.
Sensitivity control = Maximum
Oscillator level control = Mid-Rotation
Frequency = 5 Kc
Range = X0.001

With the above conditions, an unbalance of 0.001 μH should give an indication of 2.5μA over the noise level.

At a frequency of 10 Kc an unbalance of 0.0004 μH should indicate 2μA over the noise level.

At a frequency of 50 Kc an unbalance of 0.0002 μH should indicate 5μA over the noise level.

Range X0.01 Oscillator level = Maximum
5 Kc 0.001μH unbalance = 3μA over noise level
50 Kc 0.002μH unbalance = 14μA

Range X0.1 Oscillator level = Maximum
5 Kc 0.02μH unbalance = 3μA over noise level
50 Kc 0.02μH unbalance = 10μA
500 Kc 0.02μH unbalance = 18μA

Range X1.0 Oscillator level = Maximum
5 Kc 0.2μH unbalance = 14μA
50 Kc 0.2μH unbalance = 23μA

Range X10 Oscillator level = Maximum
5 Kc 2μH unbalance = 14μA
50 Kc 2μH unbalance = 23μA

When checking sensitivity, a check should be made to make sure the meter M601 does not read offscale at maximum unbalance (which is with open circuit test terminals) and with detector tuned. This adjustment is #8 on the rear of the meter, which can be set for just under full scale reading at maximum unbalance, with maximum level.

It should be noted that this adjustment will probably require readjustment each time a new tube V401 (6AK5) is put in the circuit.

4-4.8 Readings of Inductance and Resistance Standards

The basic inductance accuracy of the bridge is $\pm$0.25% plus $\frac{300}{C}$ where C is the resonating capacity of the coil at the test frequency.

The accuracy of the resistance measurements should be within the bridge specification of $\pm$3% plus $\frac{Q}{25}$.

In making inductance measurements where the resonating capacitance is small and series resistance measurements where the Q is high, the full basic accuracy statement must be used. Also, consult the reactance chart, page 4, to determine if the measurement is being made within the recommended range.

4-4.9 AC Test Level

The maximum open circuit test level on the X0.01 to X10 range should be 3.0 volts RMS $\pm$10% over the frequency range. The maximum test level on the X0.001 range should be 1.5 volts RMS with the oscillator level control set at Red Line. The level control should never be used at maximum on the X0.001 range.

SECTION V

REPLACEABLE PARTS LIST

Note:

Components in the "BRIDGE" section have not been included, since in general their replacement must be followed by adjustments that require specialized equipment and techniques.

Power Supply Section

	Reference	Description	BEC Part No.
C201	Capacitor	3200 µF @ 40V	283,155
C202	"	30/10 µF @ 475V	283,154
C203	"	0.1 µF @ 400V	236,001
C204	"	1000/1000 µF @ 15V	283,131
D201 to D208 inc.	Diode	1N538	532,008
F201	Fuse	1.2amp. 125V Buss. MDL 1.2	545,509
I201	Lamp	6V, #47	545,101
J201	Socket	12 Pin	474,106
L201	Choke	7HY	440,001
P201	Connector	Line Cord	568,101
P202	"	Plug	477,137
R201	Resistor	10KΩ 5% 1/2w	301,111
R202	"	3.5KΩ 5% 10w	312,102
R203	"	22Ω 5% 2w	303,622
S201	Switch	SPST Toggle	465,105
T201	Transformer	Power	446,026
T202	"	"	446,020
V201	Tube	6BW4	526,6BW4
V202	"	OA2	526,OA2
V203	"	"	526,OA2

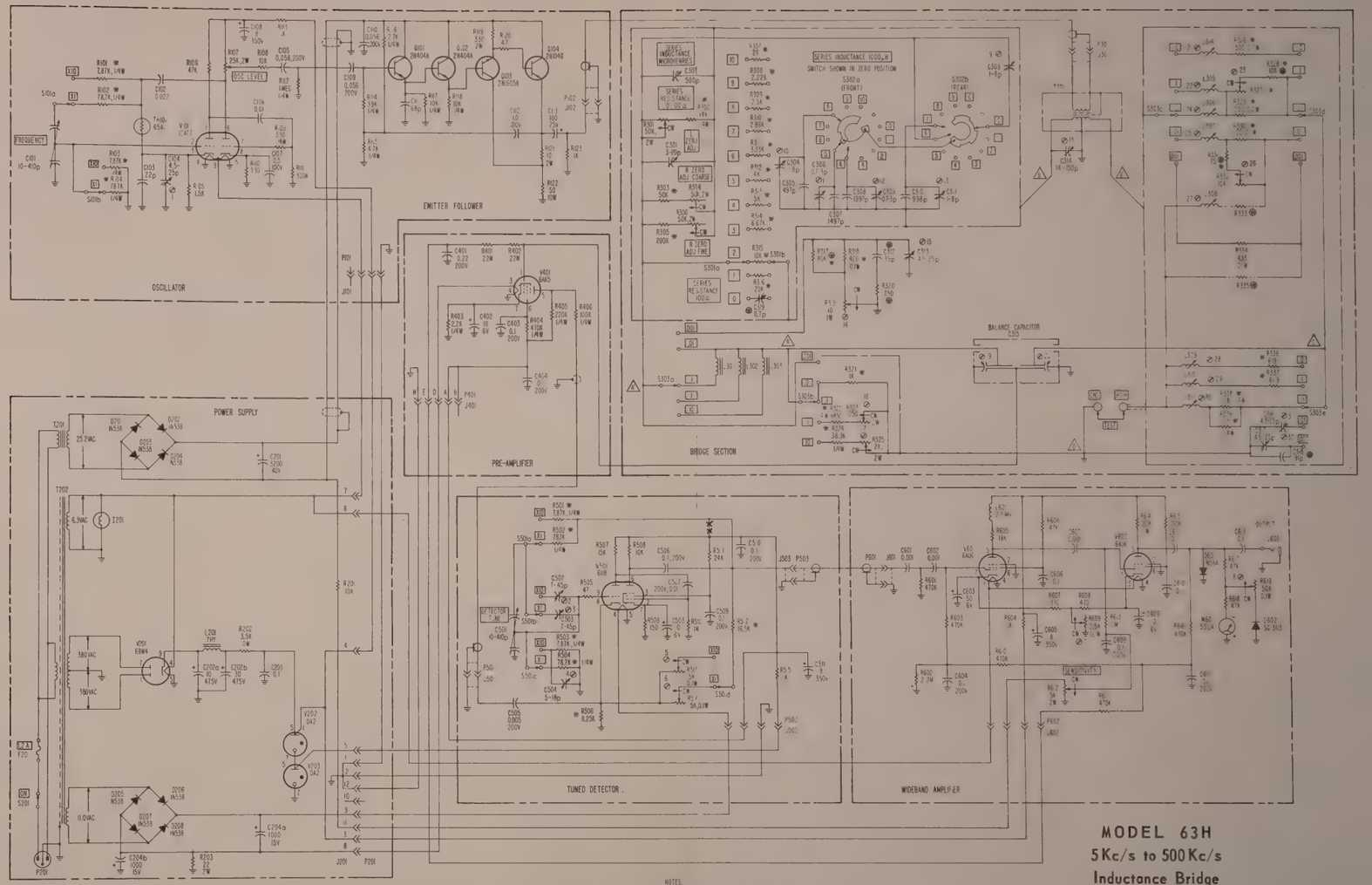
Oscillator-Emitter Follower Section

	Reference	Description	BEC Part No.
C101	Capacitor	Variable, 2 Sec. 10-410pF/sec.	275,131
C102	"	0.022 µF @ 400V	234,033
C103	"	22 pF 5% Ceramic	220,118
C104	"	Trimmer 4.5-25 pF Ceramic	281,000

	Reference	Description	BEC Part No.
C105	Capacitor	0.056 µF @ 200V	236,006
C106	"	0.01 µF @ 400V	234,021
C107	"	0.5 µF @ 100V	234,034
C108	"	8 µF @ 350V	283,126
C109	"	0.056 µF @ 200V	236,006
C110	"	0.056 µF @ 200V	236,006
C111	"	68 pF 5%	200,031
C112	"	1.0 µF @ 100V	236,007
C113	"	100 µF @ 25V	283,105
J101	Connector	Plug	477,166
J102	"	Coaxial	479,123
P101	"	Receptacle	477,145
P102	"	Coaxial	477,121
Q101	Transistor	2N404A	528,002
Q102	"	2N404A	528,002
Q103	"	2N1605A	528,005
Q104	"	2N1046	528,010
R101	Resistor	7.87KΩ 0.5%	321,278
R102	"	78.7KΩ 0.5%	321,277
R103	"	7.87KΩ 0.5%	321,278
R104	"	78.7KΩ 0.5%	321,277
R105	"	1.5KΩ 5% 1/2w	301,091
R106	"	47KΩ 5% 1/2w	301.127
R107	"	VAR. 25KΩ 2w	311,155
R108	"	10KΩ 5% 1/2w	301,111
R109	"	330Ω 5% 1/4w	300,070
R110	"	330Ω 5% 1/2w	301,075
R111	"	300KΩ 5% 1/2w	301,146
R112	"	1 MEG.Ω 5% 1/4w	300,154
R113	"	1KΩ 5% 1/2w	301,087
R114	"	39KΩ 5% 1/4w	300,120
R115	"	4.7KΩ 5% 1/4w	300,098
R116	"	2.7KΩ 5% 1/4w	300,092
R117	"	10KΩ 5% 1/4w	300,106
R118	"	10KΩ 5% 1/4w	300,106
R119	"	330Ω 5% 2w	303,626
R120	"	47Ω 5% 1/2w	301,055
R121	"	10Ω 5% 2w	303,614
R122	"	50Ω 10w	312,117
R123	"	1KΩ 5% 1/2w	301,087
S101	Switch	4PDT	466,128

	Reference	Description	BEC Part No.
TH101	Thermistor	65A1	325,001
V101	Tube	12AT7	526,12AT7
		Pre-Amplifier Section	
C401	Capacitor	0.22 µF 100V	236,005
C402	"	10 µF 6V	283,130
C403	"	0.1 µF 200V	230,116
C404	"	0.1 µF 200V	230,116
J401	Connector		477,167
P401	Connector		479,168
R401	Resistor	22 MEG.Ω 5% 1/2w	301,191
R402	"	22 MEG.Ω 5% 1/2w	301,191
R403	"	2.2KΩ 5% 1/4w	300,090
R404	"	470KΩ 5% 1/4w	300,146
R405	"	220KΩ 5% 1/4w	300,138
R406	"	100KΩ 5% 1/4w	300,130
V401	Tube	6AK5W	526,6AK5W
C501	Capacitor	VAR 2sec 10/410pF/sec	275,131
C502	"	Trimmer 7-45pF	275,114
C503	"	Trimmer 7-45pF	275,114
C504	"	Trimmer 5.5-18pF	281,001
C505	"	0.005 µF 200V	230,121
C506	"	0.1 µF 200V	230,116
C507	"	0.01 µF 200V	234,027
C508	"	10 µF 6V	283,130
C509	"	0.1 µF 200V	230,116
C510	"	0.1 µF 200V	230,116
C511	"	8 µF 350V	283,126
J501	Connector	Coaxial	479,123
J502	"		477,166
J503	"	"	479,123
P501	"	"	477,121
P502	"	"	477,145
P503	"	"	477,121
R501	Resistor	7.87KΩ 0.5%	321,278
R502	"	78.7KΩ 0.5%	321,277
R503	"	7.87KΩ 0.5%	321,278
R504	"	78.7KΩ 0.5%	321,277
R505	"	47Ω 5%	301,055

	Reference	Description	BEC Part No.
R506	Resistor	8.25KΩ 1% 1/2w	306,350
R507	"	15KΩ 5% 1/2w	301,115
R508	"	10KΩ 5% 1/2w	301,111
R509	"	150Ω 5% 1/2w	301,067
R510	"	1 MEG.Ω 5% 1/2w	301,159
R511	"	24KΩ 5% 1/2w	301,120
R512	"	16.5KΩ 1% 1/2w	306,385
R513	"	Var. 5KΩ 1/10w	311,169
R514	"	Var. 5KΩ 1/10w	311,169
R515	"	1KΩ 5% 1/2w	301,087
S501	Switch	4PDT	466,128
V501	Tube	6U8	526,6U8
		Wide Band Amplifier	
C601	Capacitor	1000pF	201,117
C602	"	1000pF	201,117
C603	"	50 μF 6V	283,145
C604	"	0.1 μF 200V	230,116
C605	"	8 μF 350V	283,126
C606	"	0.1 μF 400V	236,001
C607	"	1000pF	201,117
C608	"	0.1 μF 400V	236,001
C609	"	10 μF 6V	283,130
C610	"	0.1 μF 400V	236,001
C611	"	0.1 μF 200V	230,116
C612	"	0.1 μF 400V	236,001
C613	"	0.1 μF 400V	236,001
D601	Diode	1N58A	530,021
D602	"	SG-3113	530,009
J601	Connector	Coaxial	479,123
J602	"	Coaxial	479,114
L601	Coil	2.5mh	400,014
M601	Meter	0-50 μA	554,140
P601	Connector	Coaxial	477,121



NOTES
RESISTANCE VALUES IN OHMS AND 1/2 WATT UNLESS OTHERWISE SPECIFIED.
K=10^3
M=10^6
* PRECISION RESISTORS.
CAPACITANCE IN µF & 400V UNLESS OTHERWISE SPECIFIED.
⊘ CALIBRATION CONTROL.
● FACTORY SELECTED VALUE.

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